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Cunningham, J. and N. Herr
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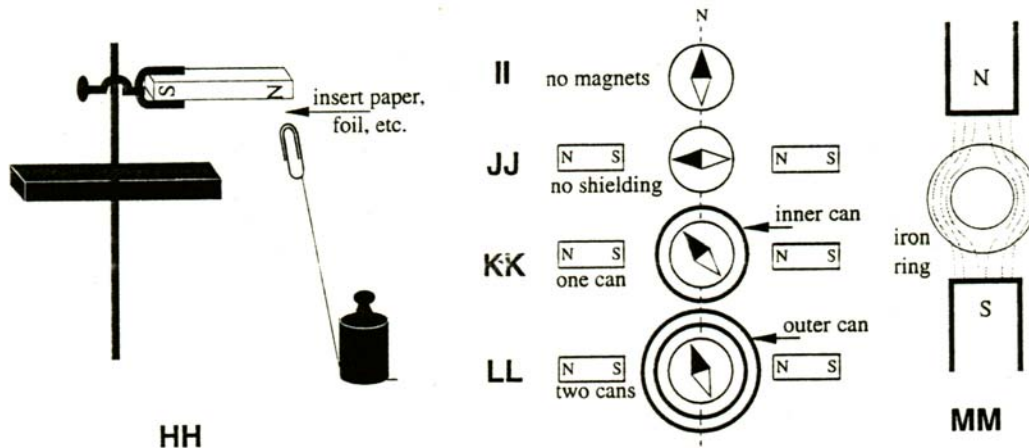
Magnetic Shielding

Concepts to Investigate: Magnetic shielding, magnetic flux density, magnetic permeability.

Materials: Strong bar magnet, paper clip, thread, "tin" cans of various sizes, compass, paper or plastic cups of various sizes..

Principles and Procedures: Whenever a nuclear weapon is detonated, it releases a brief, intense electromagnetic pulse (EMP) that propagates for thousands of kilometers and can cause serious damage to electronic equipment. It is believed that a single high-altitude detonation over the central part of the United States could seriously damage the nation's communications system and make it difficult to respond to the attack. Military analysts have warned that our electronic communication and computer systems are extremely vulnerable to an EMP attack and have therefore encouraged manufacturers to shield important electronic components from intense magnetic fields. But how can you shield something from a magnetic field? Perform the following activities to find out.

Part 1. Magnetic "floating": Support a bar magnet as illustrated in Figure HH. Attach a thread to a paper clip and suspend it below the magnet as shown. Adjust the thread to locate the position farthest from the magnet where the paper clip will still "float." Given no disturbances, the paper clip will remain positioned in space indefinitely due to magnetic lines of force between the magnet and the paper clip. Slide a small sheet of paper in the gap between the paper clip and the magnet, being careful not to touch either. Does paper interfere with the magnetic field? Repeat the process using a sheet of plastic, aluminum foil, and the lid of a "tin" can ("tin" cans are made mostly of iron). Which, if any of the above, interfered with the magnetic field and allowed the paper clip to fall?



Part 2: Magnetic Shielding: Cut the bottoms from two paper cups of different sizes, two plastic cup of different sizes, and two iron ("tin") cans of different sizes. Place a compass on a table and record the direction of magnetic north (Figure II). Now place two bar magnets 7 centimeters to the east and west of the compass so that the N-pole of one magnet faces tge S-pole of the other (Figure JJ) and record the angle of deflection. Remove the magnets, place a tine can over the compass, replace the magnets, place a second tin can around the first, replace the magnets, and again record the angle of compass-needle delection (Figure LL). Does iron, interfere with the magnetic field? Repeat the process using paper or plastic cups. Which of the substances best protects or shields the compass from the magnetic field of the bar magnets? Do two iron cans or cups provide better shielding than one alone? Figure MM illustrates how shielding material alters the magnetic lines of force and can protect instrumentation from magnetic fields. The material illustrated is known to have a high magnetic permeability because field lines permeate it more easily than the surrounding atomosphere. Which of the materials you tested has the highest magnetic permeability?

Questions

- (1) How do paper and plastic affect magnetic fields?
- (2) Which material provides the best shielding from external magnetic fields.
- (3) Which of the materials tested in Part 2 has the hifghest magnetic permeability? Explain.

FOR THE TEACHER

Magnetic Shielding

Discussion: The activity in Part 1 makes an excellent classroom demonstration because students are fascinated to see paper clips suspended in space. In addition to illustrating the effect of magnetic shielding, this activity also illustrates magnetic fields. Position a number of paper clips around the magnet and note that they align with the magnetic lines of flux. If the field of the bar magnet is sufficiently strong, it is possible to "float" paper clips in a horizontal position.

Magnetic shielding can be easily demonstrated using either of the activities discussed in this section. In addition, you may wish to show the field lines by using the set-up described in part 2 and then sprinkling iron filings over the entire surface. The iron will align with the magnetic lines of flux around the perimeter of the can, but within the can the iron will remain randomly arranged. By placing this set-up on the overhead projector, your students can clearly see the effects of magnetic shielding.

- Answers:**
- (1) Interposing either of these materials in a magnetic field has no effect on the field strength of lines of flux.
 - (2) Of the materials tested, the tin can provides the best magnetic shielding. "Tin cans" are made of iron with a thin coat of tin.
 - (3) Iron alters magnetic lines of flux more than the other substances, indicating it has the greater magnetic permeability.